Behavioural Processes 133 (2016) 37–43

Contents lists available at ScienceDirect

Behavioural Processes

journal homepage: www.elsevier.com/locate/behavproc

Evidence for positive, but not negative, behavioral contrast with wheel-running reinforcement on multiple variable-ratio schedules

Terry W. Belke[a,*], W. David Pierce[b]

[a] Mount Allison University, Sackville, New Brunswick, Canada
[b] University of Alberta, Edmonton, Alberta, Canada

ARTICLE INFO

Article history:
Received 6 September 2016
Received in revised form 25 October 2016
Accepted 1 November 2016
Available online 4 November 2016

Keywords:
Wheel-running reinforcement
Multiple schedule
Variable ratio
Behavioral contrast
Lever pressing
Rats

ABSTRACT

Rats responded on a multiple variable-ratio (VR) 10 VR 10 schedule of reinforcement in which lever pressing was reinforced by the opportunity to run in a wheel for 30 s in both the changed (manipulated) and unchanged components. To generate positive contrast, the schedule of reinforcement in the changed component was shifted to extinction; to generate negative contrast, the schedule was shifted to VR 3. With the shift to extinction in the changed component, wheel-running and local lever-pressing rates increased in the unchanged component, a result supporting positive contrast; however, the shift to a VR 3 schedule in the changed component showed no evidence of negative contrast in the unaltered setting, only wheel running decreased in the unchanged component. Changes in wheel-running rates across components were consistent in showing a compensation effect, depending on whether the schedule manipulation increased or decreased opportunities for wheel running in the changed component. These findings are the first to demonstrate positive behavioral contrast on a multiple schedule with wheel running as reinforcement in both components.

Behavioral contrast refers to a change in the rate of response in one stable or unchanging component of a multiple schedule that occurs when the reinforcement conditions in the other changed component are altered (McSweeney and Weatherly, 1998; Reynolds, 1961; Weatherly et al., 1998). On a multiple schedule of reinforcement, the animal alternates between two schedules of reinforcement, each in effect for a specified duration and each component signaled by a different stimulus. Positive contrast refers to an *increase* in rate of response in the unchanged component when the reinforcement conditions in the changed component are worsened, as when the ongoing schedule of reinforcement is changed to extinction or the reinforcement amount is decreased. Positive contrast, in the form of an increase response rate, would occur in the unchanged component if a multiple (MULT) VI 60 s VI 60 s was changed to MULT VI 60 s Extinction (EXT). Negative contrast refers to a *decrease* in the rate of response in the stable, unchanged component when the reinforcement conditions are enhanced in the changed component. Thus, negative contrast would occur if multiple (MULT) variable-interval (VI) schedules were changed from MULT VI 60 s VI 60 s to MULT VI 60 s VI 5 s and response rate decreased in the unchanged VI 60 s component (Killeen, 2014; Williams, 2002).

Typically, a contrast effect is generated when food reinforcement is programmed in both components of the multiple schedule. Behavioral contrast, however, does not depend on the particular resource scheduled in each component, as contrast has been shown when qualitatively different reinforcement is arranged in the two components (Beninger and Kendall, 1975; McSweeney et al., 1988; Weatherly et al., 1998). One question that has not been settled is whether travel or locomotion scheduled as reinforcement for operant behavior produces contrast effects when arranged on a multiple schedule. To date, only one study has partially addressed this question. Premack (1969) arranged an activity wheel equipped with two retractable levers and a retractable drinkometer. Four rats were placed on a multiple schedule (MULT VI 30 s VI 30 s) with wheel running as the reinforcement in one component and drinking [milk] as reinforcement in the other component. In the wheel-running reinforcement component, rats pressed one of the retractable levers on a VI 30 s schedule for opportunity to run for 3 s on the wheel. In the drinking component, rats pressed the other lever for the opportunity to drink milk for 3 s. To assess contrast, the lever pressing for wheel running requirement for two rats was changed from VI 30 s to extinction (EXT); that is a brake on the wheel no longer released following completion of the usual lever-pressing requirement. The schedule of wheel-running reinforcement for the other two rats

* Corresponding author at: Department of Psychology, Mount Allison University, Sackville, New Brunswick, E4L 1C7, 506 364 2459, Canada.
E-mail address: tbelke@mta.ca (T.W. Belke).

http://dx.doi.org/10.1016/j.beproc.2016.11.003
0376-6357/

was changed from VI 30 s to time out (i.e., bar did not extend) as a different procedure to remove or terminate reinforcement. After responding on extinction or time out, all rats were returned to the multiple VI 30 s VI 30 s schedule with wheel running and drinking in the respective components, and then once again returned to extinction or time out in an ABAB reversal design.

Results showed that with the initial shift to extinction or time out, lever pressing for wheel running decreased for both rats on the extinction procedure and dropped to a zero level in the rats on time out. Lever pressing for drinking increased for both rats placed on extinction and for one rat placed on time out. Based on these findings, Premack (1969) argued for a positive contrast effect in 3 of the 4 rats. Upon reversal to the multiple VI 30 s VI 30 s schedule with both wheel running and drinking operative, however, lever pressing for drinking did not decrease as would be expected. With the reinstatement of extinction or time out once again, lever pressing for drinking further increased for the three rats that previously had shown positive contrast under these conditions. Although the increase in responding in the unchanged, drinking component is consistent with positive contrast, the failure of responding for drinking to decrease when the wheel-running reinforcement was reinstated is troubling, and suggests that an alternative procedure is required to investigate behavioral contrast using wheel-running reinforcement on a multiple schedule.

The objective of the current study was to further investigate the occurrence of contrast with wheel-running reinforcement using a multiple schedule resembling that used by Belke and Pierce (2015). Unlike Premack's (1969) experiment, we programmed the opportunity to run in a wheel as reinforcement for lever pressing in both components, eliminating confounding of changes in rate of reinforcement with the quality of reinforcement (drinking milk versus wheel running). In addition, the duration of the opportunity to run was set at 30 s instead of the 3 s used by Premack. In this regard, Belke (2006) has shown that at very short wheel-running durations such as 2.5 s or below, the value of an opportunity to run decreases markedly, allowing for individual differences in the effectiveness of running as reinforcement. In addition, we programmed a variable ratio (VR) 10 schedule of reinforcement for both components to allow for generalizing the results from the current study to other recent experiments on wheel-running reinforcement with a multiple schedule (Belke et al., 2015, 2016; Belke and Pierce, 2015) that used the VR procedure. Typically, VI rather than VR schedules are used to investigate contrast as the increase in responding in the unchanged component is less likely to produce a change in the reinforcement rate with VI schedules. With VR schedules, the rate of reinforcement varies directly with the rate of responding. Importantly, however, contrast has been demonstrated in multiple schedules with VR schedules (Hellenthal and Marcucella, 1978), indicating that the use of VR schedules should not be a limitation. Finally, the current study investigated both positive and negative contrast using wheel-running reinforcement in both components. To demonstrate positive contrast, rats in the current study were initially exposed a MULT VR 10 VR 10 schedule then shifted to a MULT VR 10 EXT schedule. Subsequently, the rats were returned to the MULT VR 10 VR 10 schedule before being shifted to a MULT VR 10 VR 3 schedule to demonstrate negative contrast. We hoped to show that contingencies arranged to run on a wheel interact, showing both types of contrast effects.

1. Method

1.1. Subjects

Nine female Long-Evans rats obtained from Charles River Breeding Laboratories in St. Constant, Quebec served as subjects. At the start of the experiment, they were approximately 1 year 9 months old and had previously participated in wheel-running reinforcement studies. In their colony room, the rats were individually housed in polycarbonate cages (483 mm × 267 mm × 203 mm). Heat-treated beta chips and paper towel were used as bedding. Lighting in the colony room was on a 12-h light/dark cycle (lights on at 0730). Rats were fed Prolab R-M-H 3000 lab chow and provided distilled water. Distilled water was freely available at all times within the home cage. Food was restricted to an amount that would maintain the rats at 260 ± 10 g that was approximately 87% of an adult female ad-lib body weight for this strain. This research was conducted in accord with the guidelines set forth by the Canadian Council on Animal Care under a protocol approved by the Mount Allison Animal Care Committee.

1.2. Apparatus

Three Lafayette Instrument activity wheels (350 mm in diameter) were used in the present experiment. The wheels were located in sound-attenuating shells (600 mm × 500 mm × 480 mm) equipped with fans for ventilation and to reduce extraneous noise. 24 v DC lights were mounted on the sides of the wheel frame 175 mm above the base of the wheel frame, to illuminate the interior of the wheel chamber. A microswitch attached to the wheel frame recorded wheel revolutions. The wheels were also equipped with a solenoid-operated brake consisting of a rubber tip on a metal shaft that would contact the outer rim of the wheel and bring it to a stop.

A metal panel (170 mm high by 170 mm wide by 2 mm thick) equipped with a retractable mouse lever, two yellow LED stimulus lights, and a liquid receptacle was attached to the 70 mm by 90 mm opening on each wheel frame using Velcro strips. A retractable mouse lever was used because of the constraint of size of the opening of the wheel. The lever was 16 mm wide, 95 mm from the base of the panel, and extended 7 mm beyond the surface of the panel through an opening in the panel. Yellow LED stimulus lights, 3 mm in diameter, were located 5 mm to the left and right of the opening for the retractable lever. The liquid receptacle (55 mm by 32 mm by 37 mm) was located to the left of the retractable lever and the base of the receptacle opening was 75 mm above the base of the panel. Sucrose solution was contained in a cylindrical dispenser and delivered into the receptacle by a solenoid valve controlled by a computer. The dispensers were 37 mm in diameter, 40 mm long, and held in place by a metal clamp above the liquid receptacle. Experimental events were controlled and data recorded by Borland Turbo Pascal 4.0 programs run on IBM PC computers interfaced to the wheels through their parallel ports.

1.3. Procedure

1.3.1. Training

1.3.1.1. Training. Prior to the current study, the rats were trained to press a lever for the opportunity to run and to run in a wheel to produce a drop of sucrose solution. The objective of this initial training was to prepare the rats for a multiple schedule with lever pressing on a VR 10 schedule for wheel-running reinforcement in one component and running a fixed number of revolutions to produce sucrose reinforcement in the other component. The training procedure, described in detail in Belke and Pierce (2015), will not be reiterated here. Upon completion of this training, the rats participated in an investigation of the effects of manipulating sucrose concentration in the sucrose reinforcement component of the multiple schedule.

Following completion of this study, the multiple schedule was changed for the current study. In the current study, rats pressed the retractable lever on a VR 10 schedule for the opportunity